CHANGES IN THE SAPROXYLIC COLEOPTERA FAUNA OF FOUR WOOD PASTURE SITES

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ABSTRACT

The results of repeated surveys of saproxylic beetle assemblages at four sites from 1988–2006 were used to explore changes over time in whole-site assemblages and the within-site distributions of individual species. Site assemblages changed in different ways between surveys and in one case the change could be linked to site management. Of the more frequently recorded species, *Agrilus laticornis* (Illiger) and *Conopalpus testaceus* (Olivier) showed large variations in local population levels, while *Euglenes oculatus* (Paykull) had more stable populations and was probably more sedentary in habits. Of the rarer species, the presence of *Aulonothroscus brevicollis* (Bonvouloir) was recorded in one tree on two occasions over a period of ten years, while *Tropideres sepicola* (Fabr.) seemed to have successfully colonized new habitat over a range of at least 200m within the same time period. It is suggested that heartrot species may be less mobile within a site than species that are associated with the early stages of decay under bark and in aerial dead branches.

INTRODUCTION

There is now a great deal of interest in the conservation of saproxylic invertebrates (Harding & Rose, 1986; Alexander, 1999; Fowles *et al.*, 1999; Read, 2000) and there have been a number of individual site quality evaluations in England based on intensive surveys (Lott & Alexander, 1992; Lott, 1995; Lott *et al.*, 1999; Levey, 2000; Denton & Alexander, 2002; Denton, 2003; Damant & Kirby, 2005). However, there have been few published studies on how the saproxylic assemblages of a site change over time, even in response to the introduction of a new management regime. In 1998, a survey was initiated of two areas of Sherwood Forest, Nottinghamshire, with different management histories (Lott, 1999). Two compartments of an area, which retained ancient trees, but which had been planted with conifers, were found to have lower values for saproxylic species richness than two adjacent compartments of an SSSI, which had been left intact. The survey was designed as the baseline for a programme to monitor the effects on saproxylic assemblages of removing conifers from the plantation area, so a repeatable sampling protocol was used and the first follow-up survey was carried out in 2006. By coincidence, the author was asked to carry out repeat surveys on two other saproxylic beetle sites in 2006. Although the original sampling protocols were not as tightly defined as at Sherwood, the fieldwork methods employed were sufficiently similar to allow a comparison of results between survey years for each site.

METHODS

Four sites are included in this study:

1. Birklands West and Ollerton Corner SSSI, Nottinghamshire (SK66), is an area of Sherwood Forest with relict ancient oaks and planted with conifers that were selectively removed in the mid nineties to conserve the oaks and their fauna. Two

sampling areas were visited five times each in 1998 and again in 2006. Approximately one and a quarter hours were spent in each sampling area on each visit.

2. Birklands and Bilhaugh SSSI, Nottinghamshire (SK66), is an intact area of Sherwood Forest. Two sampling areas adjacent to the Birklands West SSSI were visited in 1998 and 2006 using the same sampling protocol as above. Grazing has recently been introduced to these areas together with bracken control, but large areas of habitat retain a relatively closed canopy when compared with the majority of classic wood pasture sites.
3. Croome Park National Trust property, Worcestershire (SO84) is a former landscape park with a relatively low density of trees for wood pasture, but located in a wider landscape that is rich in mature oaks by comparison with most areas of the British countryside. The trees formerly sat in an arable matrix, but this is being progressively converted to pasture. The site was visited five times in 1996 and five times in 2006. The records are allocated to eight distinct areas of the site, although these areas do not correspond to sampling units that received equal sampling effort.
4. Donington Park SSSI, Leicestershire (SK42), is the surviving third of a mediaeval deer park that is still grazed by deer. The site was visited eight times in 1988 and three times in 2006. Three one and a quarter hour per visit sampling areas were used in 2006 and the 1988 records were retrospectively split into the same areas.

In all surveys a standard suite of fieldwork methods was used as listed in Table 1, except that grass traps were not used at Donington in 2006. Consequently, earlier records derived from this method are not used in the analysis for Donington.

There is no standard checklist of saproxylic beetles. Fowles *et al.* (1999) limited their list mainly to species that were restricted to wood decay habitats only. Alexander (2002) was more inclusive. Saproxylic species are defined here as species that habitually breed in habitats associated with wood decay. This definition includes species that also occur in other habitats.

Assemblage parameters were calculated for each site in each year. The parameters used are as follows:

- Species richness (S) is a count of the number of saproxylic species.
- The Index of Ecological Continuity (IEC) is the sum of scores allocated to species according to their dependence on the historical continuity of wood decay habitat (Alexander, 2004).

Table 1. Sampling methods

Technique	Target species
Beating dead branches	A wide range of saproxylic species
Searching under bark	Subcortical species
Dissection of fungal fruiting bodies	Fungus-feeders
Grass traps placed in tree hollows	Species associated with the nests of birds and ants
Tullgren funnel extraction from samples of rotten wood	Species associated with heartrot especially small species difficult to see in the field

- The Species Quality Factor (SQF) (Eyre & Rushton, 1989) is here based on scores allocated to species according to their conservation status as listed in the RECORDER computer package (see also Hyman, 1992, 1994). The species scores are averaged in order to avoid the influence of sampling effort, which affects cumulative scores. SQF has similar properties to the derivative Saproxylic Quality Index (Fowles *et al.* 1999), but it takes account of the more inclusive definition of saproxylic species by counting all the species listed by Alexander (2002).
- Species turnover between each survey period, t, was calculated using:

$$t = (l + g) / (S_1 + S_2)$$

where l = number of species lost, g = number of species gained, S_1 and S_2 = species richness in each survey period (Magurran, 2004).

Variations in the population levels of individual species over all four sites were explored for the more commonly recorded species by comparing the sampling areas occupied by each species in each year. For each species, the percentage of recorded sampling areas that were occupied in both survey periods, p, was taken to be a coarse measure of the level of local population stability. Species with high p values would be species with stable local population levels, which rarely fall below the threshold at which they can be recorded by sampling.

A measure of increase or decline in the distribution of each species, d, was calculated using the formula

$$d = \log_{10} (N_{2006}/N_{prev})$$

where N_{2006} is the number of sampling areas occupied in 2006 and N_{prev} is the number of sampling areas occupied in previous surveys. A score of one represents a tenfold increase in distribution, while a score of -1 represents a tenfold decrease in distribution.

Some rarer species were recorded in more than one year and the extent to which they move around the site was assessed individually.

Results

Assemblage statistics

The recorded species richness S for all sites was lower in 2006 than in earlier surveys (Table 2). S is well known to be influenced by sampling effort and, in the case of Donington Park, the reduced number of visits in 2006 would undoubtedly have been a contributory factor to differences in recorded species richness. For all sites, the recorded species richness could also be affected by sampling efficiency related to weather and habitat accessibility. The Species Quality Factor, SQF, is less affected by sampling factors and the parity of values for Donington suggests that the conservation quality of that site is being maintained despite the drop in Index of Ecological Continuity, IEC, which is influenced by sampling effort in the same way as species richness. By contrast, the large drop in all three parameters, S, IEC and SQF at Croome Park may reflect real changes in the fauna there. The increases in IEC and SQF at Birklands West indicate an improvement in conservation quality following removal of the conifer matrix surrounding the ancient oaks. This has opened up the habitat and attracted several species associated with bark and peripheral decay, which require insolated breeding habitat (Lott, 2006). This

Table 2. Assemblage statistics for each site

	S		IEC		SQF		
Site	1988–1998	2006	1988–1998	2006	1988–1998	2006	t
Croome Park, Worcs.	109	81	53	29	294	249	0.45
Donington Park, Leics.	53	46	17	12	204	204	0.66
Birklands West, Notts.	56	55	16	27	220	258	0.59
Birklands & Bilhaugh, Notts.	75	67	25	27	227	240	0.48

management-induced change in assemblage composition is probably also responsible for the relatively high species turnover, t, at the site. The highest species turnover was recorded at Donington, but it is not known whether this is connected with the longer interval between surveys, the differences in sampling effort between the two surveys or the relatively small size of the site.

Population fluctuations in more commonly recorded species

Table 3 shows the degree to which populations of different commonly recorded species have varied over all four sites between different survey periods. Only five species (13% of the total) were recorded in more areas in 2006 than in previous surveys, while 26 species (68%) were recorded in fewer areas. These figures do not necessarily reflect any underlying trends; rather the conditions that obtained in 2006 compared to previous survey years. In this respect, 2006 seems to have been a particularly good year for the subcortical staphylinid, *Phyllodrepa vilis* (Erichson), and the late successional click beetle, *Stenagostus rhombeus* (Olivier), but a terrible year for four species of saproxylic Cantharidae that underwent the steepest drops in numbers of areas occupied.

No fewer than eight species had a p value of zero. In other words, they were not recorded in the same sampling area twice. Some of these are species that seem to have undergone a general increase or decline. However, two species associated with aerial dead branches, *Agrilus laticornis* (Illiger) and *Conopalpus testaceus* (Olivier), have relatively stable populations on a large scale, while undergoing fluctuations in abundance at a local scale. The heartrot species, *Euglenes oculatus* (Paykull), had the highest p value. It seems to have relatively stable populations at a local scale and is possibly sedentary in nature, only infrequently moving into new areas.

Changes in the distribution of rarer species

Ampedus cardinalis (Schiödte), *Stenichnus godarti* (Latreille) and *Euthia formicetorum* (Reitter) were recorded in 1996 at Croome, while *Plectophloeus nitidus* (Fairmaire) was recorded in 1988 at Donington. All these Red Data book heartrot species were recorded in fallen trees or boughs, which by 2006 had decayed to the point where they no longer provided suitable habitat. They were not rediscovered at their respective sites in 2006. However, it cannot be concluded that these species had become extinct on these sites. Some heartrot species, such as *E. oculatus* (Paykull)

Table 3. Changes in the distribution of frequently recorded species between sampling areas. Nomenclature follows Duff (2007).

Species	Increase/ decline, d	Stability index, p	No. areas occupied	Favoured microhabitat
Phyllodrepa vilis (Erichson) (Staphylinidae)	0.54	0	9	under bark
Stenagostus rhombeus (Olivier) (Elateridae)	0.24	10	10	old logs
Grammoptera ruficornis (Fabr.) (Cerambycidae)	0.22	14	7	aerial dead branches
Salpingus planirostris (Fabr.) (Salpingidae)	0.12	62	13	aerial dead branches
Cerylon histeroides (Fabr.) (Cerylonidae)	0.08	22	9	under bark
Anobium fulvicorne (Sturm) (Anobiidae)	0.00	27	11	aerial dead branches
Scolytus intricatus (Ratzeburg) (Curculionidae)	0.00	14	7	under bark
Phloeopora corticalis (Gravenhorst) (Staphylinidae)	0.00	20	5	under bark
Gabrius splendidulus (Gravenhorst) (Staphylinidae)	0.00	43	7	old logs/under bark
Phloeonomus punctipennis Thomson (Staphylinidae)	0.00	20	5	under bark
Anaspis garneysi Fowler (Scraptiidae)	0.00	50	8	aerial dead branches
Leptusa fumida (Erichson) (Staphylinidae)	0.00	60	5	fungi/under bark
Leiopus nebulosus (L.) (Cerambycidae)	−0.05	55	11	aerial dead branches
Melanotus villosus (Geoffroy) (Elateridae)	−0.08	22	9	heartrot
Anaspis fasciata (Forster) (Scraptiidae)	−0.08	38	8	aerial dead branches
Anaspis maculata (Fourcroy) (Scraptiidae)	−0.08	69	13	aerial dead branches
Cartodere nodifer (Westwood) (Latriidae)	−0.10	0	9	fungi/mouldy bark
Dryocoetes villosus (Fabr.) (Curculionidae)	−0.10	43	7	under bark
Euglenes oculatus (Paykull) (Aderidae)	−0.10	80	5	heartrot
Calodromius spilotus (Illiger) (Carabidae)	−0.11	45	11	aerial dead branches
Dasytes aeratus Stephens (Melyridae)	−0.12	40	10	aerial dead branches
Orthocis alni (Gyllenhal) (Cisidae)	−0.12	40	5	aerial dead branches
Anaspis frontalis (L.) (Scraptiidae)	−0.18	11	9	aerial dead branches
Ptinella errabunda Johnson (Ptiliidae)	−0.18	25	8	heartrot/under bark
Agrilus laticornis (Illiger) (Buprestidae)	−0.18	0	5	aerial dead branches
Cis vestitus Mellié (Cisidae)	−0.20	44	9	aerial dead branches
Paromalus flavicornis (Herbst) (Histeridae)	−0.22	14	7	heartrot/under bark
Anaspis rufilabris (Gyllenhal) (Scraptiidae)	−0.22	60	5	aerial dead branches
Conopalpus testaceus (Olivier) (Melandryidae)	−0.40	0	7	aerial dead branches
Abraeus perpusillus (Marsham) (Histeridae)	−0.40	17	6	heartrot
Phyllodrepa ioptera (Stephens) (Staphylinidae)	−0.40	17	6	under bark
Anaspis regimbarti Schilsky (Scraptiidae)	−0.44	15	13	aerial dead branches
Dromius quadrimaculatus (L.) (Carabidae)	−0.48	20	10	aerial dead branches
Salpingus ruficollis (L.) (Salpingidae)	−0.60	0	5	aerial dead branches
Malthinus flaveolus (Herbst) (Cantharidae)	−0.60	0	5	aerial dead branches
Malthinus frontalis (Marsham) (Cantharidae)	−0.60	0	5	heartrot?
Malthinus seriepunctatus Kiesenwetter (Cantharidae)	−0.85	14	7	aerial dead branches
Malthodes minimus (L.) (Cantharidae)	$-\infty$	0	6	aerial dead branches

have adults which can easily be found with a beating tray, but others spend most of their life cycle close to the breeding habitat and are much more difficult to find. An externally sound veteran tree with no dead branches may contain heartrot that provides habitat for several species, but they are effectively inaccessible to the ground-based fieldworker without recourse to canopy fogging or trapping. On the other hand, veteran trees in an advanced stage of decay with large fissures in their bole have often lost much of their quality heartrot habitat through exposure to the elements. In order to gain access to good quality heartrot habitat, the fieldworker has to find a tree in an intermediate stage of decay or one with a freshly snapped bough. Such trees are comparatively rare, so many species present on site will evade notice. Similarly, the Red Data book heartrot species, *Euplectus nanus* (Reichenbach), *E. tholini* Guillebeau and *Microscydmus minimus* (Chaudoir) were found in different areas of Sherwood Forest in different years, but this does not necessarily mean that they move frequently between areas to colonise new habitat. They are just as likely to have relatively sedentary habits and be widely distributed on site, but their discovery is largely dependent on the chance of finding accessible habitat.

The Red Data book species, *Aulonothroscus brevicollis* (Bonvouloir), was beaten from three trees at Croome in 1996. Most specimens were found on one particular externally sound oak. It was still present in numbers on the same tree in 2006 and can evidently survive for over a decade in a healthy tree containing the right habitat.

In 1996 two specimens of the Red Data book species, *Tropideres sepicola* (Fabr.), were beaten from a dead branch on two separate dates from an oak tree at Croome. In 2006 it could not be found on this tree, but was present in large numbers on the dead branches of a fallen oak about 200m away, where it was unrecorded in 1996. It is likely that this species had successfully colonized new habitat following a short-range dispersal. *Tropideres sepicola* develops in decaying branches (Alexander, 2002) and its dispersal behaviour is probably typical of a range of species, which develop under bark and in aerial dead branches in an early stage of decay. These species require a frequent supply of fresh habitat and their populations are probably more mobile than heartrot species.

Discussion

It is not possible to draw many inferences with any confidence from a study of changes at just four sites based on only two visits. Nevertheless, these results do indicate that several parameters can be used to recognize differences in the dynamics of individual site assemblages and that individual species can vary in the way that their within-site distributions and populations change over time. The results also illustrate the utility of the Species Quality Factor and its variants as a tool for comparing assemblages that have received different amounts of sampling effort.

In general, species richness and the Index of Ecological Continuity can only be used to compare survey results derived from roughly equal sampling efforts. The IEC was not designed for detecting trends, but for evaluating site lists built up over a period of several years, so that their species richness curves approach an asymptote. Lott (1999) used further parameters for monitoring saproxylic assemblages at Sherwood. They were based on the species richness of ecological sub-assemblages defined by breeding habitat, *e.g.* heartrot and fungal fruiting bodies. This approach is now being developed by Natural England's ISIS invertebrate assemblage project (Webb & Lott, 2006).

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